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Thermal and Corrosion Analysis of an Electroplated Material

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ABSTRACT: The aim of this work is to reduce the overall cost of heat exchangers by avoiding the use of costlier metals which may have more corrosive resistance property even though having low thermal conductivity property which may be used for chemical industry to handle corrosive chemicals by making corrosion protective coating through electroplating and to analyse the corrosion resistance property and the thermal performance of electroplated material through ANSYS.

KEYWORDS: Aluminium pipe, Nickel electroplating, salt spray test, glass wool.

I. INTRODUCTION

Heat exchanger has been employed in various industry fields such as foodstuff industries, dairy product, heavy industries, seawater plant, chemical industry and power generation plant since its invention. Especially, surface corrosion of Heat exchangers for seawater plant (OTEC equipment) and chemical fields might be causative of low performance for every kind of leakages. It results from exposure to various kinds of chemical steam and saline environment. Also it lets down durability and feasibility. To avoid corrosion, titanium and Nickel material was employed as heat exchanger element. The titanium and Nickel are relatively more expensive than other light metal, so it is too difficult to be adapted to heat exchangers. Hence, manufacturing of low cost as well as high efficiency heat exchangers become more challenging. To accomplish these goals, it is necessary to improve the corrosion resistance of aluminum material to adapt various suitable methods. Corrosion protection of heat exchangers is very important since these systems might work in environments containing different types of aggressive species.

II. LITERATURE REVIEW

E.S. Puchi-Cabrera et al (2006)

carried out a study to investigate the fatigue and corrosion-fatigue behavior of a 7075-T6 aluminum alloy coated with an electroless Ni-P (EN) deposit, in the as-plated condition, of approximately 38–40 μm in thickness and a high P content, of approximately 18 wt%. The results obtained, show that the EN coating can give rise to a significant improvement in the fatigue and corrosion-fatigue performance of the substrate, depending on the testing conditions. When the coated system is tested in air, it is observed that the increase in fatigue properties decreases as the alternating stress applied to the material increases.

L. Fedrizzi et al (2008)

In their work evaluates the barrier properties of two coatings that represent the state of the art for the protection in the heat, ventilating, air conditioning/refrigerating field (HVAC/R) electrophoretic coating (E-coating) using epoxy resin

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and spraying of polyurethane coating with addition of metallic pigments. The ability of the coatings to cover the surface of heat exchanger has been evaluated by means of optical microscopy in order to highlight critical zones of the system for the application of the coatings. The electrochemical behaviour of coated heat exchangers has been studied by means of electrochemical impedance spectroscopy in 3.5% NaCl solution. The local electrochemical behaviour of coating defects has been investigated using the electrochemical micro-cell, which enables to perform potentiodynamic polarization measurements on single defects. E-coatings evidenced difficulties to provide uniform thickness of the coating at the extremities of the fins.

Jong-Soon KIM, etal (2009)

It investigate the correlations between thermal and physical properties through thermal conductivity measurements, hardness tests, salt spray tests (AASS) among the surface treatment samples named K20, K40 with thickness of 20, 40 μ m respectively and raw sample named K00. In thermal conductivity measurements, there are little differences among the samples as K00, K20 and K40, they exhibit 153.39, 150.69 and 149.76 W/(m·K), respectively. According to hardness tests, K00, K20 and K40 exhibit 87.9, 259.7 and 344.8 in Vickers values. In the result of salt spray tests to examine the effects on corrosion resistance, K00, K20 and K40 exhibit the grade of 3–5, 2.0–9.8 and 10, respectively. The mutual relation of the above results was analyzed.

M.A. Rahmat etal (2013)

In their study analyze the fatigue behaviour of Al 7075-T6 fastener holes with symmetrical through slits. The holes were coated with electroless nickel (EN) plating with a high phosphorous content of 10– 13 wt% and a thickness of 40 μ m. Un coated open-hole, EN coated open-hole, uncoated bolted hole and EN coated bolted hole specimens were fatigue tested. Bolted samples were clamped with a high tightening torque of 7Nm. The established S–N curves showed 282–1348% improvements in the fatigue life due to the combined effect of EN coating and bolt clamping, depending on the level of maximum alternating stress. Excellent adhesion was observed between the coating and the aluminium substrate along the crack path.

IV. OBJECTIVE OF PROPOSED WORK

- To analyse the corrosion resistance and the thermal performance of Nickel electroplated material in Heat Exchangers used to handle corrosive chemicals.
- To reduce the overall cost of heat exchangers by avoiding costlier metals.
- To decrease the leakage due to the flowing corrosive chemicals.

V. METHODOLOGY FOR THERMAL AND CORROSION ANALYSIS

Process of nickel electroplating:

For the nickel electroplating of the aluminium pipe first the aluminium pipe needs to be coated with the copper. For nickel plating first the amp is to 0.14 to 0.15 in the amplifier case then the aluminium is dipped in electro cleaner solution for the cleaning of the aluminium.

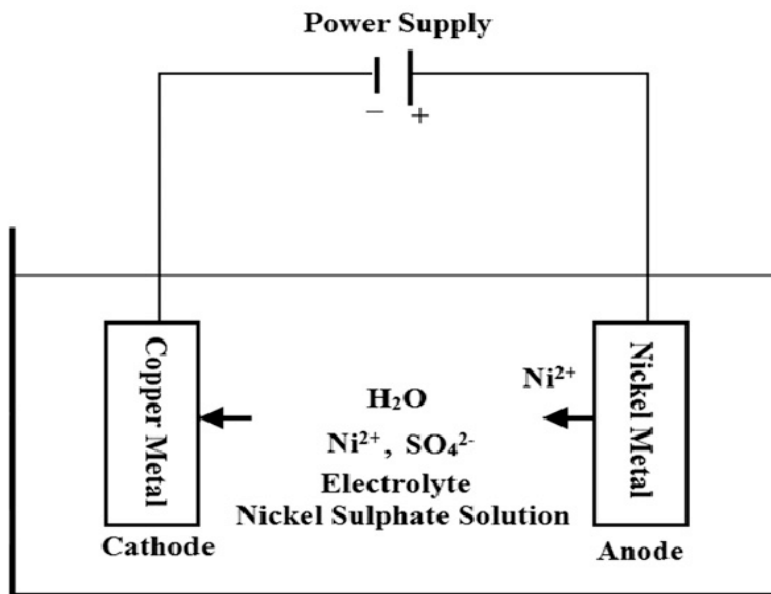
Then the aluminium piece is dipped in to the special copper solution for copper to be deposited on to it this process takes about 3 to 5 mins and then it is rinsed in the electroforming copper solution for about 1 hour in the solution which has a magnetic stirrer attached to it after one hour copper is deposited on it and then the nickel is plated on it using the electrochemical deposition by using the anode and cathode configuration by using the electrolyte.

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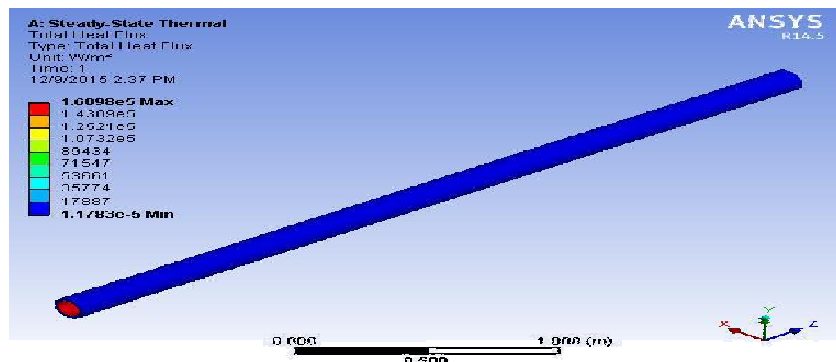
ANALYSING

Steady state Thermal Analysis of Heat Exchanger done by ANSYS 14.5 software:

The procedure of Analysing is given below:

1. Open → Ansys → Steady State Thermal
2. Engg. data → All Mechanical Properties entered.
3. Geometry → Import saved step file geometry
4. Geometry → Set material property for imported material
5. Meshing → settings for fine mesh → right mesh → generate mesh
6. Generate Mesh → Apply convection load areas.
7. Solution → Temperature → Film Coefficient results
8. Solution → right click → solve
9. Save results.

The Material property changed for Nickel, Aluminium, and Copper and results were obtained. The heat flux value for Nickel Aluminium and Copper analyzed and the result is shown



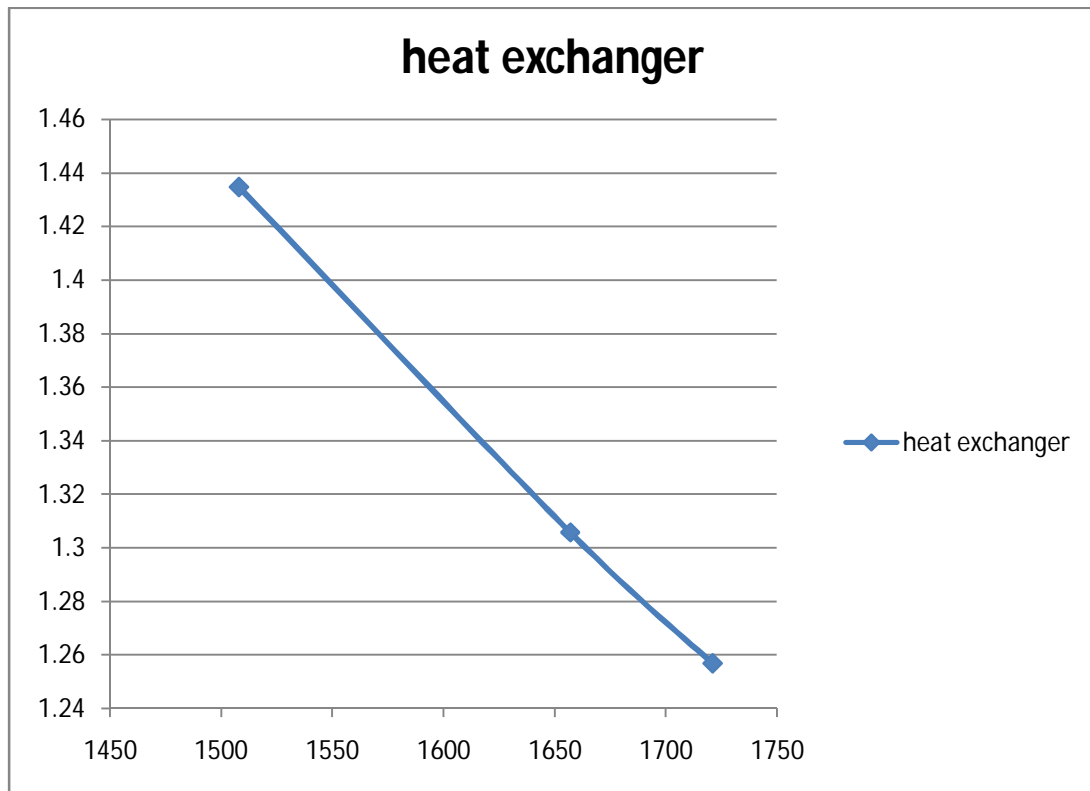
Variation in Overall heat transfer coefficient with respect to coating thickness

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VII. CONCLUSION

The aim of this work is to reduce the heat exchanger cost as well as size by electroplating a corrosive resistant which is having lower thermal conductivity material over material having less corrosion resistance property but having higher thermal conductivity.

The thermal flow for the coated condition analyzed theoretically and through analysis software.

The results were summarised as follows.

- By using material having higher thermal conductivity the area of the heat exchanger can be reduced by 9% in case of Aluminium and 12 % in case of using Copper as a base material.
- While going for improving the corrosion resistance property through electroplating there is a reduction of heat flow while comparing the heat flow of base material.
- The reduction in heat flow depends upon the coating material thickness.
- For every 0.25mm increase in coating thickness there is a increase of 0.3% in Heat exchanger area.

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